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New Stars on the Block

Ray Jayawardhana
Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138
Electronic mail: rayjay@cfa.harvard.edu

ABSTRACT

Groups of young stars located in the solar neighborhood have recently received a lot of attention. These stars, which are $\lesssim$ 10 million years old, can provide insights into the birth of stars and planetary systems. For example, the TW Hydrae Association is just at the age when planets are believed to form, while MBM12 represents an earlier stage. In this Perspective, I briefly discuss recent research in this field.

Much glory in astronomy comes from probing the farthest reaches of the universe for the most exotic beasts. But poking around closer to home for more prosaic objects has its own rewards–such as finding small groups of relatively isolated young stars destined for the limelight. Over the past few years, one such group, known as the TW Hydrae Association, has attracted quite a following, as evidenced by the high attendance of a special session during the recent American Astronomical Society meeting.

The reason for this widespread interest is that the TW Hydrae group, and others like it in the solar neighborhood, may tell us a lot about the birth of stars and planetary systems. The TW Hydrae Association, in particular, appears to be at the age at which planet formation is believed to occur. It may even be possible to take a picture of a newborn planet around one of these stars.

The star TW Hydrae first caught astronomers' attention back in 1978 (1). George Herbig noted that it had the earmarks of a young low-mass star, or so-called T Tauri star, including variability in brightness, a strong Hα emission line in its spectrum, and a high abundance of lithium (an element that is easily fused in nuclear reactions and thus does not survive in older stars). Most T Tauri stars are found in clouds of gas and dust, the presumed sites of their birth, such as the Orion nebula. Curiously, TW Hydrae is not.

Subsequent work added further evidence for TW Hydrae's youth and indications for the presence of a circumstellar disk and revealed four other stars in the same region of the sky with similar characteristics (2, 3). Three years ago, Kastner et al. (4) suggested on the basis of strong x-ray emission from all five systems that the group forms a physical association at a distance of roughly 150 light-years. Since then, at least seven more stars have been identified as candidate members of the TW Hydrae Association, on the basis of the same signatures of youth and the same motion across the sky as the original five members (5).

The group consists mostly of low-mass stars, typically a few tenths of the mass of the sun, and includes several binary systems as well as one remarkable quadruple system, HD 98800, in which two pairs of stars appear to orbit a common center of gravity. There is only one higher mass star, HR 4796A, which is twice as massive as the sun and about 20 times as luminous. The TW Hydrae stars are estimated to be roughly 10 million years (My) old (4, 6), older than most T Tauri stars in star-forming regions, which are usually only about 1 My old.

The origin of the TW Hydrae Association remains a bit of a mystery. There is no obvious parent cloud (1, 2), and the stars are dispersed across some 20 on the sky and 60 light-years in radial distance, making it difficult to determine their birthplace (7). Were they born in a low-mass cloud that has since dispersed? Or could these stars be escapees from known star-forming regions (8)? The slow velocities of TW Hydrae stars through space favor in situ formation, suggesting that clouds may disperse more quickly than previously thought (9).

Being the nearest group of young stars (and three times closer than the nearest previously known star-forming region), the TW Hydrae Association offers a unique opportunity to study the evolution of circumstellar disks and planet formation. Furthermore, its estimated age of 10 million years provides a strong constraint on disk evolution time scales and fills a substantial gap in the age sequence between previously known 1-My-old T Tauri stars and 50-My-old nearby open clusters. It has been suggested that circumstellar disks evolve from dense, actively accreting structures to sparse, passive remnants within about 10 My (10). During this transition, grains may assemble into planetesimals, or the disk may be cleared by planets. The circumstellar disks of the TW Hydrae stars exhibit a wide variety, from classical T Tauri accreting disks, to planetary debris systems, to systems without measureable disk emission at near-infrared wavelengths implying cleared-out inner disks (11). A spectacular debris disk with a central cavity has been directly imaged around HR 4796A (12, 13). The diverse disk properties suggest that the TW Hydrae stars are at an age when disks are rapidly evolving through coagulation of dust and dissipation of gas.

If planets have indeed formed around these stars, it may be possible to detect them with large ground-based telescopes. Adaptive optics, a technique that corrects for the blurring of the atmosphere, allows one to search within several astronomical units (AU) of the TW Hydrae stars (an AU is the average distance between Earth and the sun) for planets a few times as massive as Jupiter. Newborn planets are quite warm, and such objects should therefore be sufficiently luminous to be detected at the distance of this stellar group. In other words, we should be able to look for newborn giant planets located at distances from their parent stars similar to those of giant planets in our own solar system. At least one brown dwarf, a "failed star" not massive enough to ignite hydrogen fusion, has already been found in the TW Hydrae Association (14), and searches for objects of even lower mass are under way (15).

The commotion surrounding the TW Hydrae Association has prompted astronomers to look for other groups like it. The all-sky survey done by the Roentgen Satellite (ROSAT) has been particularly useful in identifying isolated young stars through their x-ray emission. Of the recently discovered stellar groups, MBM12 and Eta Chamaeleontis (Eta Cha) are particularly interesting. At about 200 light-years, MBM12 is the second-nearest group of young stars after the TW Hydrae

Association, containing only 30 to 100 solar masses of gas. It does not appear to be gravitationally bound and may be breaking up on a time scale comparable to the sound-crossing time (16). Thus, in a few million years, the young stars in MBM12 may appear as isolated objects not associated with any cloud material, very similar to how the TW Hydrae stars appear at present. On the basis of ROSAT detections followed by ground-based optical spectroscopy, Hearty et al. (17) have identified eight low-mass young stars associated with MBM12. Most of them are classical T Tauri stars and are likely to be a younger population than the TW Hydrae members. Eta Cha is a cluster of a dozen young stars first identified in x-ray measurements (18). As with the TW Hydrae group, Eta Cha is far from any substantial cloud. Its members are much less dispersed than the TW Hydrae stars and may represent an epoch intermediate between MBM12 and TW Hydrae Association.

The exploration of these nearby groups of young stars is progressing at a breathtaking pace. In the past few months, telescopes in Arizona, Hawaii, Chile, and Australia were trained on them with a variety of optical, infrared, and radio instruments. Many questions remain, but the prospects they offer for learning about star formation in the solar neighborhood and the origin and diversity of planetary systems ensure that interest in them will not wane quickly.

References and Notes

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